

**In Regards to:**

**DA 16-442  
April 22, 2016**

**COMMENT SOUGHT ON LIGADO'S MODIFICATION APPLICATIONS**

**IB Docket No. 11-109; IB Docket No. 12-340**

**Comments/Petitions to Deny Due: May 23, 2016**

**Oppositions Due: June 6, 2016**

**Replies Due: June 16, 2016**

Their Own Data Shows Adverse Effects

# Ligado Results Regarding Trimble R9 Reference Receiver

## The Trimble R9 Is a Reference Receiver Most Often Used to Provide Differential Corrections to Other Receivers

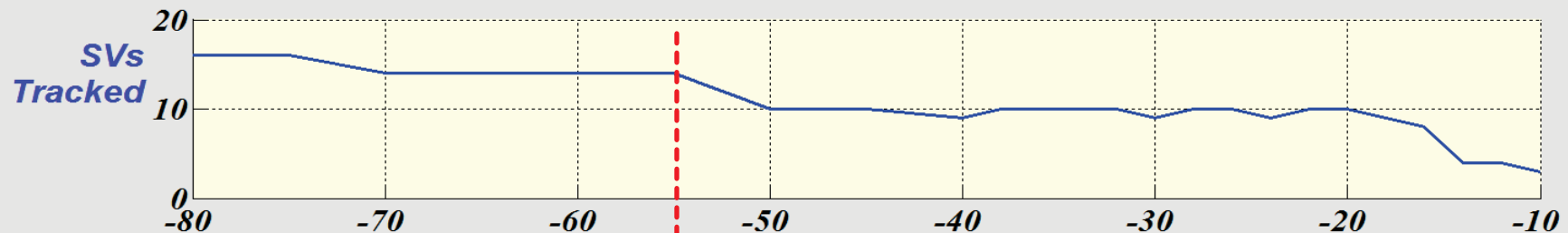
### 1000's Of R9 Receivers are Operationally Deployed

- Typically:
  - Operates at a Precisely Surveyed Location
  - Key Performance Metrics Are:
    - Pseudorange Measurement Accuracy
    - Carrier Phase Tracking Accuracy
    - Number of Satellites Tracked
  - Also Provide Precise Time Output
- Any Adverse Effects on a Single Reference Receiver Can Impact Many Users
  - Reference Data Is Used to Correct Many Rover Receivers (Potentially)

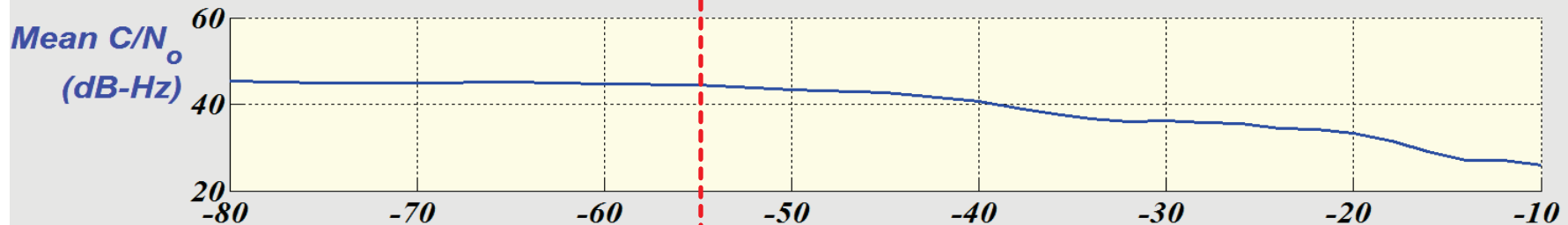
# Trimble R9 Reference Receiver Shows Sensitivity to LTE Downlink (BaseStation) Interference When Operating with Standard Antenna

Data from page 165 of Ligado Roberson and Associates Test Data (AS FILED May 11, 2016).pdf

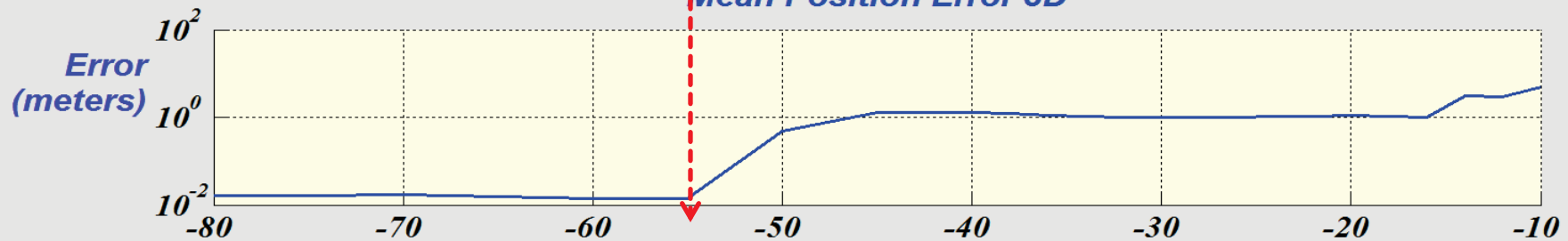
Trimble R9 with GA530 Antenna, Live Sky, LTE Downlink 1526-1536 MHz  
GPS Satellite Count



Mean  $C/N_o$



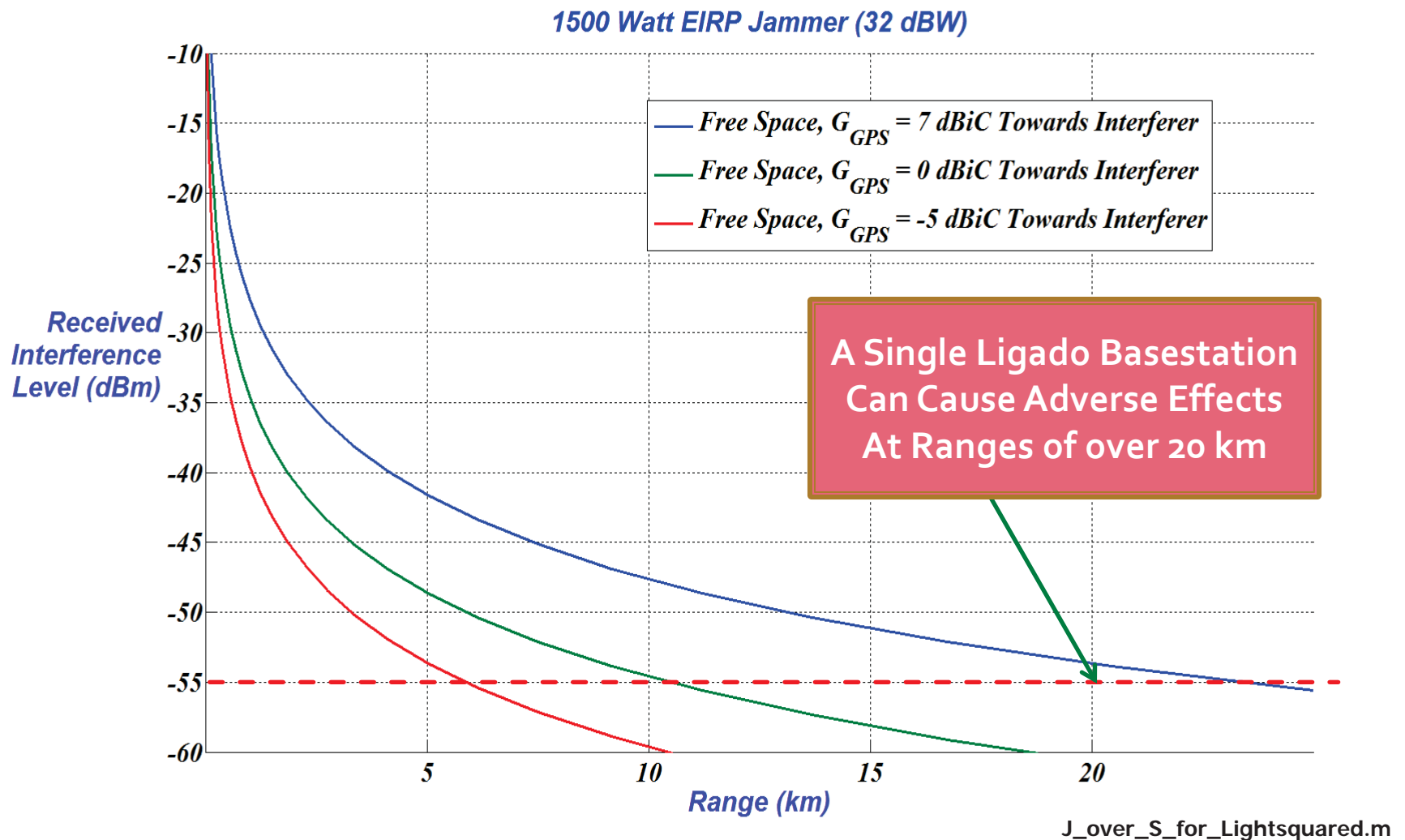
Mean Position Error 3D



LTE Signal Level (dBm)

ligado.m

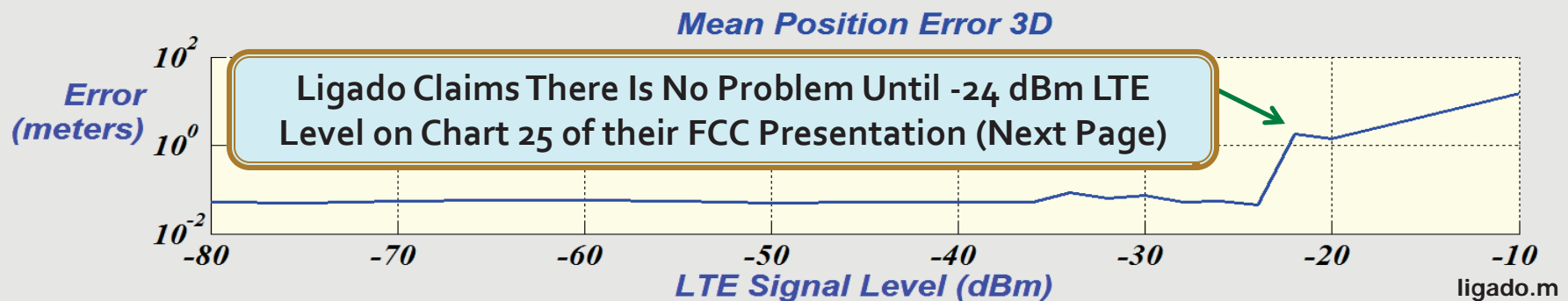
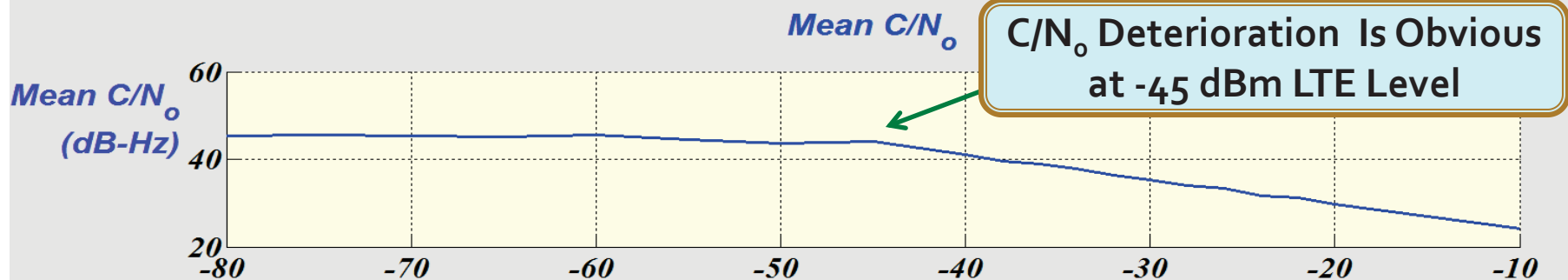
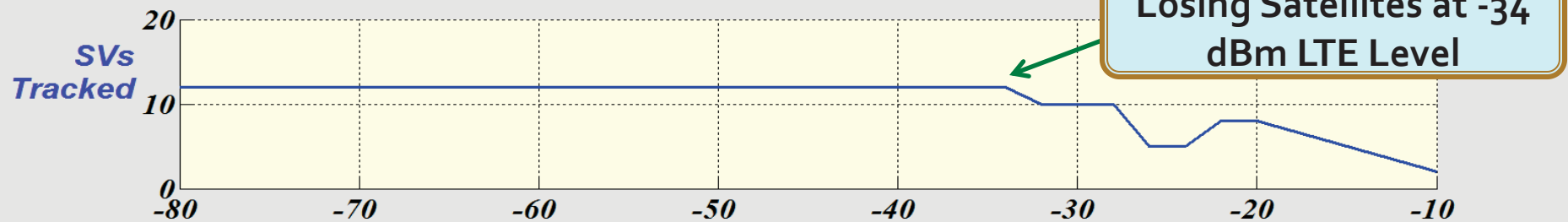
# A 1500 Watt Source Can Yield -55 dBm at Ranges from 6 to 23 km



# Trimble R9 Reference Receiver Shows Sensitivity to LTE Uplink (Handset) Interference When Operating with Standard Antenna

Data from page 167 of Ligado Roberson and Associates Test Data (AS FILED May 11, 2016).pdf

Trimble R9 with GA530 Antenna, Live Sky, LTE Uplink 1627.5-1637.5 MHz  
GPS Satellite Count



# High Precision Devices

## Condition: Live Sky

### Test Performance under the Ligado GPS Proposal

Device	Test	Antenna	1526-1536 MHz Downlink	1627.5-1637.5 MHz Uplink	1646.5-1656.5 MHz Uplink	1670-1680 MHz Downlink
NavCom SF-3050	Live Sky	Internal	No Impact	No Impact	No Impact	No Impact
Trimble R9	Live Sky	GA 530 Filtered	-55 dBm* No Impact	-24 dBm* No Impact	No Impact No Impact	No Impact No Impact
Trimble R8	Live Sky	Internal	No Impact	No Impact	No Impact	No Impact

“No Impact” means that, with LTE received powers corresponding to the transmit power levels under the Ligado GPS proposal, there was no impact on the device performance compared to those KPI measurements with GPS alone.

\*The Trimble R9 with the GA 530 antenna was compatible with the 1526-1536 MHz band with up to -55 dBm of LTE power, and with the 1627.5-1637.5 MHz band with up to -24 dBm of LTE power. When retested with a filtered antenna, the Trimble R9 was compatible with the proposed LTE emissions.

Copy of Chart 25 from Ligado  
Ex-Parte Presentation Filed 11  
May 2016 with Red Highlight  
Added

# Interference from Handsets Is More Difficult to Assess

- Handsets Adjust Transmit Power Depending on Path loss to BaseStation
- Number of Handsets in an Area Is Highly Variable
- Handsets Can Get Very Close To Reference Receivers
  - Reference Stations Are Not Always At Protected Sites
  - Construction Projects Often Place Reference At Edge

# Not All Installations Are At Protected Locations



Google Map

Receiver Status

- Activity
- Position
- Position (Graph)
- Vector
- Google Map
- Google Earth
- Identity
- Receiver Options

Satellites

Data Logging

Receiver Configuration

I/O Configuration

Bluetooth

Network Configuration

Security

Firmware

Help

Refresh Interval: 5 Minutes

Map Satellite

Miniature Golf?

Reference Receiver

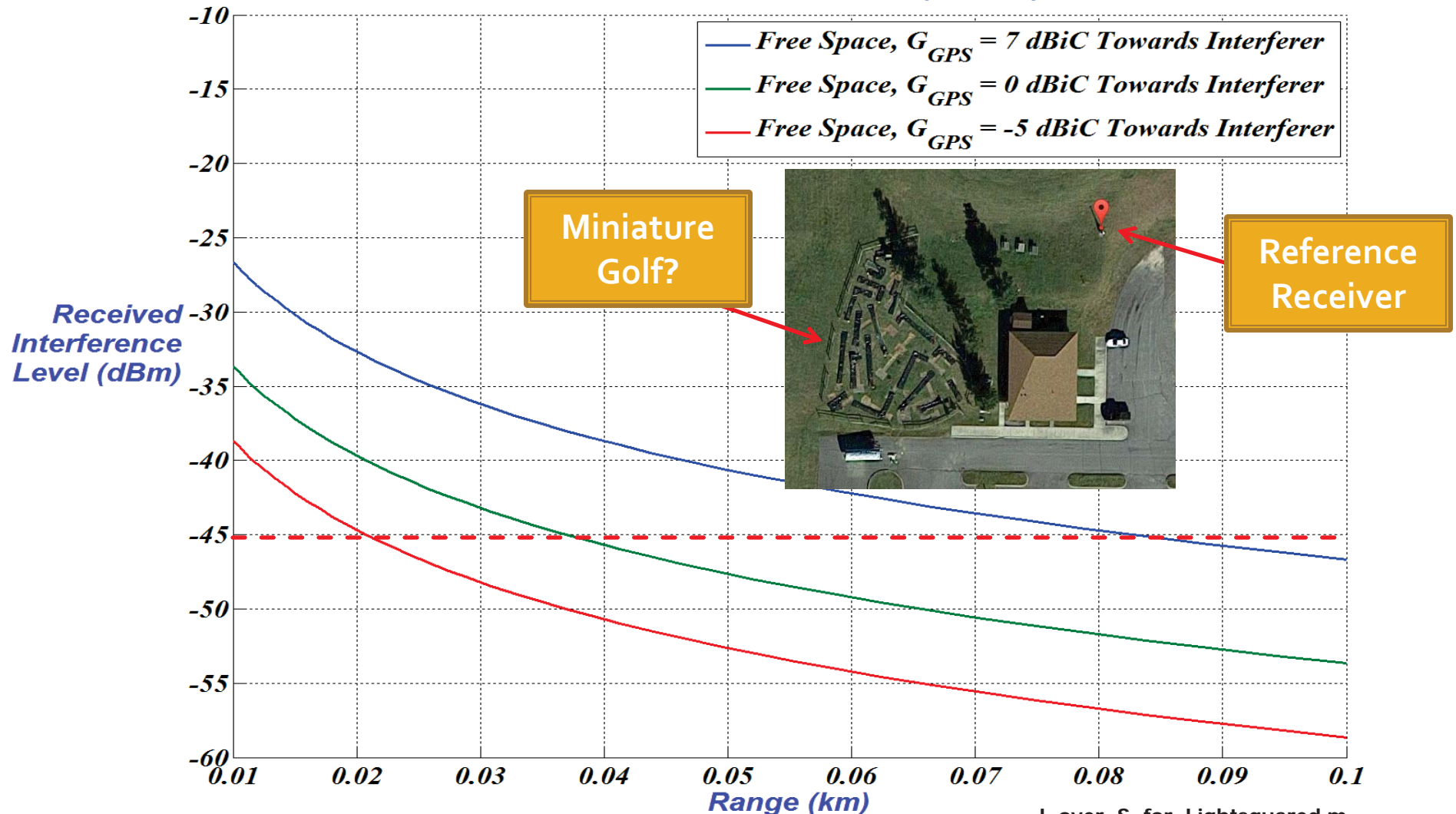
Nature Center

An aerial satellite view of a golf course area. A red pin is placed on a grassy area, labeled "Reference Receiver". A yellow box labeled "Miniature Golf?" points to a small structure on the left. Another yellow box labeled "Nature Center" points to a building in the center. The interface includes a sidebar with navigation options and a top bar with the Trimble logo and WVCV 4922K62079.

# A Single 200 mWatt Source Can Yield -45 dBm at Ranges from 20 to 85 meters

Handsets Are Likely to Get Within This Range

One 0.2 Watt EIRP Jammer (-7 dBW)



# Finally, In Fairness...

- Ligado Also Tested the R9 with a Javad Filter Added
  - Results Showed No Deterioration in Measured Metrics
- BUT, There are 10,000's of Reference Receivers of Various Types Operationally Deployed
  - Dependent Systems are Critically Reliant on Many of These Reference Receivers
  - Symptoms of Interference are Often Non-Obvious
    - E.g. A Medical Paging System turned itself OFF as a result of GPS Interference (2007 San Diego Incident)